

SECTION 512

PRECAST PRESTRESSED CONCRETE MEMBERS

512.1 GENERAL

This work shall consist of furnishing and placing precast prestressed concrete members in accordance with the details shown on the plans and as specified in these specifications and the Supplementary Specifications. This work shall include the manufacture, transportation, and storage of girders, slabs, and other structural members of precast prestressed concrete and shall also include the placing of all precast prestressed concrete members. The members shall be furnished complete including all concrete, prestressing steel, bar reinforcing steel, and incidental materials in connection therewith. Prestressing shall be performed by either pretensioning or post-tensioning methods. The method of prestressing to be used shall be optional with the CONTRACTOR, subject to the requirements specified in these specifications. Prior to casting any members to be prestressed, the CONTRACTOR shall submit to the ENGINEER for review complete details of the method, materials, and equipment he proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel from that shown on the plans. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members, pressure grouting, materials, and equipment. For any rearrangement of stress force pattern, the stress calculations shall be submitted for approval by the ENGINEER.

512.2 REFERENCES

512.2.1 ASTM

A 416

A 421

512.2.2 This Publication:

SECTION 101

SECTION 510

512.3 CONCRETE

Concrete construction shall conform to the provisions in Section 510 of these specifications or as provided in the Supplementary Specifications. The design of the precast prestressed concrete

members is based on the use of concrete having a minimum compressive strength or strengths at 28 days of not less than the values shown on the plans. The CONTRACTOR shall be responsible for furnishing concrete for prestressed members which contains not less than 6 sacks of cement per cubic yard of concrete, which is workable and which conforms to the strength requirements specified. Batch proportions shall be determined by the CONTRACTOR. The compressive strength of the concrete will be determined from concrete test cylinders cured under conditions similar to those affecting the member. The use of admixtures for the purpose of producing high strength at an early date shall be subject to the approval of the ENGINEER. In no case shall the admixture contain calcium chloride. Aggregate for use in the manufacture of concrete for prestressed members may be 1 inch maximum or 3/4 inch maximum, in lieu of 1 1/2 inch maximum, at the option of the CONTRACTOR. Concrete shall not be deposited in the forms until the ENGINEER has inspected the placing of the reinforcement, enclosures, anchorages, and prestressing steel. The concrete shall be vibrated internally or externally, or both, as required to consolidate the concrete. The vibrating shall be done with care and in such manner that displacement of reinforcement, enclosures, and prestressing steel will be avoided. Holes for anchor bars and for diaphragm dowels which pass through the member, openings for connection rods, recesses for grout, and holes for railing bolts shall be provided in the members in accordance with the details shown on the plans. Where diaphragm dowels do not pass through the member, the dowels may be anchored in the member by embedment in the concrete or by means of an approved threaded insert. Forms for interior cells or holes in the members shall be constructed of a material that will resist breakage or deformation during the placing of concrete and will not materially increase the weight of the member. Lifting anchors may be installed in members to be placed in bridge decks provided that all portions of the anchor above the concrete are removed after the members are placed. Side forms for prestressed members may be removed after a period of 24 hours, provided arrangements satisfactory to the ENGINEER are made for curing and protecting the concrete. However, side forms may be removed as soon as the transfer strength has been attained. The steam-curing method or other approved methods

may be used for curing precast prestressed concrete members in lieu of water curing. Steam curing, if elected by the CONTRACTOR, shall conform to the following provisions:

512.3.1 After placement of the concrete, members shall be held for a minimum 2-hour presteaming period. If the ambient air temperature is below 50°F, steam shall be applied during the presteaming period to hold the air surrounding the member at a temperature between 50°F and 90°F.

512.3.2 All exposed surfaces of the members shall be kept wet continuously during the holding and curing period.

512.3.3 The steam shall be saturated low pressure and shall be distributed uniformly over all exposed surfaces of the member but shall not directly impinge on the exposed concrete surfaces.

512.3.4 The steam hood shall be equipped with temperature recording devices that will furnish an accurate continuous permanent record of the temperatures under the hood during the curing period. The position of the temperature devices shall be approved by the ENGINEER.

512.3.5 During application of the steam, the temperature gradient within the enclosure shall not exceed 40°F per hour. The curing temperature shall not exceed 150°F and shall be maintained at a constant level for sufficient time necessary to develop the required compressive strength.

512.3.6 The members shall be protected from sudden temperature and moisture changes for at least 48 hours after completion of steam curing.

512.4 PRESTRESSING STEEL

512.4.1 Prestressing steel shall be high-tensile wire conforming to ASTM A 421, high-tensile wire strand conforming to the following requirements: the cross sectional steel area of wire strand shall be within 0.003 square inch of the nominal steel areas shown in Table I of ASTM A 416. In the event the CONTRACTOR elects to use a wire strand manufactured to a higher breaking strength than is specified in ASTM A 416, such higher strength strand shall, in addition, conform to the requirements of Table 512.4.1.

512.4.2 High-tensile strength alloy bars shall be thermal stress relieved to produce a suitable metallurgical structure

and shall be individually proof tested during the process of manufacturing to a minimum of 90 percent of the manufacturer's minimum guaranteed ultimate strength. The mechanical properties of the completed bars shall be as per Table 512.4.2.

512.4.3 Bars of different ultimate strengths shall not be used interchangeably in the same member, unless otherwise permitted by the ENGINEER. In handling and shipping bars, every care shall be taken to avoid bending, injury from deflection, scraping, or over-stressing of the bars. All damaged bars will be rejected. When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the specified minimum ultimate tensile strength. Failure of any one sample to meet this requirement will be cause for rejection of the heat of bars and lot of couplers. The location of couplers in the member shall be subject to approval by the ENGINEER. All wire or strand to be post-tensioned shall be:

512.4.3.1 Protected from corrosion during shipping by a factory treatment or processing.

512.4.3.2 Protected against abrasion during shipment and handling.

512.4.3.3 Installed in members after steam curing, when steam curing is used.

512.4.3.4 Grouted in the enclosures within 48 hours after the wire or strand has been tensioned.

512.4.4 Wires shall be straightened if necessary to produce equal stress in all wires of wire groups or parallel lay cables that are to be stressed simultaneously or when necessary to insure proper positioning in the enclosures. Where wires are to button-headed, the buttons shall be cold formed symmetrically about the axis of the wires and shall develop the full strength of the wire. No cold-forming process shall be used that causes indentations in the wire. When the button-headed wire assembly is tested as a unit in tension, at least 90 percent of the failures at or above the minimum guaranteed ultimate strength of the wire shall occur in the wire and not in the buttons. All prestressing steel shall be protected against rust and other corrosion and damage and shall be free of all dirt, scale, and pits due to rust, oil, grease,

TABLE 512.4.1

STRENGTH REQUIREMENTS

BREAKING STRENGTH REQUIREMENTS

Nominal Diameter (inches)	3/8	7/16	1/2
Breaking Strength (lbs.), min.	23,000	31,000	41,000
Nominal Steel Area (sq. in.)	0.058	0.116	.1531
Nominal Weight, 1000 ft., (lbs.)	292	400	525

YIELD STRENGTH REQUIREMENTS

Nominal Diameter (inches)	3/8	7/16	1/2
Initial Load (lbs.)	2,300	3,100	4,130
Maximum Load 1% Extension (lbs.)	19,600	26,400	35,100

TABLE 512.4.2

MECHANICAL PROPERTIES

	Regular Grade	Special Grade
Ultimate tensile strength psi, min.	145,000	160,000
Yield strength, measured by the 0-7 percent extension under load method, psi, min	130,000	140,000
Elongation in 20-bar diameters after rupture, percent, min.	4.0	4.0
Reduction of area, percent, min.		
Modulus of elasticity at 70 percent of the manufacturer's minimum guaranteed ultimate strength psi, min.	25 x 10 ⁶	25 x 10 ⁶
Diameter tolerances shall conform to ASTM A 29.		

and other deleterious substances when finally encased in concrete or grouted in the member.

512.5 ANCHORAGES AND DISTRIBUTION

512.5.1 All post-tensioned prestressing steel shall be secured at the ends by means of approved anchoring devices. The anchors shall be of such nature that they will not kink, neckdown, or otherwise damage the prestressing steel. The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. Anchoring devices for all post-tensioned prestressing steel shall be of the permanent type. Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 2 inches inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with grout and finished flush. When headed wires are used, the outside edge of any hole for prestressing wire through a stressing washer or through an unthreaded bearing ring or plate shall not be less than 1/4 inch from the root of the thread of the washer or from the edge of the ring or plate.

512.5.2 Distribution plates or assemblies shall conform to the following requirements:

512.5.2.1 The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch, and suitable grillage of reinforcing steel shall be used in the stressed area.

512.5.2.2 Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material or cause visible distortion, as determined by the ENGINEER, in the anchorage plate when 100 percent of the ultimate load is applied.

512.5.3 Should the CONTRACTOR elect to furnish anchoring devices of a type which are sufficiently large and which are used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

512.6 ENCLOSURES

Enclosures for prestressing steel shall be metallic and mortar-tight and shall be accurately placed at the locations shown on the plans or approved by the ENGINEER. In lieu of metallic enclosures, openings for prestressing steel may be formed by means of cores or ducts composed of rubber or other suitable material that can be removed prior to installing prestressing steel. All enclosures or openings or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing.

512.7 PRESTRESSING

512.7.1 All prestressing steel shall be tensioned by means of hydraulic jacks. Each jack shall be equipped with a pressure gauge having an accurately reading dial at least 6 inches in diameter and each jack and its gauge shall be accompanied by a certified calibration chart showing the relationship between gauge readings and stress in the ram for both ascending and descending movements of the ram.

512.7.2 The tensioning of prestressing steel in any post-tensioned member and the cutting or releasing of prestressing steel in any pretensioned member shall not be performed until tests on concrete cylinders indicate that the concrete in the member has attained a compressive strength of not less than the value shown on the plans.

512.7.3 Subject to prior approval by the ENGINEER, a portion of the total prestressing force may be applied to a member when the strength of the concrete in the member is less than the value shown on the plans and the member may then be moved. Approval by the ENGINEER of such partial prestressing and moving shall in no way relieve the CONTRACTOR of full responsibility for successfully constructing the members.

512.7.4 The cutting and releasing of prestressing steel in pretensioned members shall be performed in such an order that lateral eccentricity of prestress will be a minimum. The prestressing steel shall be cut off flush with the end of the member and the exposed ends of the prestressing steel shall be heavily coated with roofing asphalt or coal tar.

512.7.5 Post-tensioning will not be permitted until it is demonstrated to the satisfaction of the ENGINEER that the prestressing steel is free and unbonded in the enclosure.

512.7.6 The tensioning process as applied to post-tensioned members shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured at all times. A record shall be kept of gauge pressures and elongations at all times and shall be submitted to the ENGINEER for approval.

512.7.7 Prestressing steel in post-tensioned members shall be tensioned by simultaneous jacking at each end of the assembly, except as provided by the following:

512.7.8 Jacking from one end of the assembly will be permitted on simple span members under 65 feet in length, provided the calculations show that the maximum temporary tensile stress at the center of the span will not be more than 70 percent of the ultimate tensile strength of the prestressing steel.

512.7.9 For simple span members 65 feet and over in length, jacking from one end will be permitted, provided the calculations and also field tests demonstrate that the maximum stresses at the center of the span will not be more than 70 percent of the ultimate tensile strength of the prestressing steel.

512.7.10 Unless otherwise permitted by the ENGINEER, half of the prestressing steel in each member shall be stressed from one end of the span and the other half from the opposite end. Determination of the jacking stresses shall be supported by calculations or both calculations and field tests when specified, prepared by the CONTRACTOR. The CONTRACTOR shall submit his calculations to the ENGINEER for approval and prior to making field tests, shall submit details of his proposed gauges and load devices for determining the jacking load at each end of the test prestressing unit to the ENGINEER for approval. The stress at the center will be calculated from the average of the end test loads. Jacking stresses within 2 percent of the specified values will be considered satisfactory.

512.7.11 The friction coefficients on Table 512.7.11 shall be used in calculating friction losses. K represents the wobble of the ducts, and U represents the curvature in draped cables.

512.7.12 The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 75 percent of the ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the plans but in no case shall the initial stress exceed 70 percent of the ultimate tensile strength of the prestressing steel.

512.8 BONDING AND GROUTING

Post-tensioned prestressing steel shall be bonded to the concrete by pressure grouting and enclosures or openings. All prestressing steel to be bonded to the concrete shall be free of scale and pits due to rust, dirt, oil, grease, and other deleterious substances. Grouting equipment shall be capable of grouting to a pressure of at least 100 pounds per square inch. The grouting shall consist of neat cement and water conforming to the provisions in Section 101, Portland Cement Concrete. The grout shall completely fill the enclosure or opening. All enclosures or openings shall be clean and free of all foreign materials that would impair bonding of the grout. Each enclosure or opening shall be thoroughly flushed out with water and blown out with air or cleaned by other approved methods immediately prior to grouting. After post-tensioned prestressing steel has been pressure grouted, the member shall not be moved or otherwise disturbed until at least 24 hours have elapsed.

512.9 SAMPLES FOR TESTING

512.9.1 Sampling and testing shall conform to the specifications of ASTM A 416 and ASTM A 421 and as specified in this section. Samples from each size and each lot of prestressing steel wires and bars, from each manufactured reel of prestressing steel strand, and from each lot of anchorage assemblies and bar couplers to be used shall be furnished for testing. All materials for testing shall be furnished by the CONTRACTOR at his expense. The CONTRACTOR shall have no claim for additional compensation in the event his work is delayed awaiting approval of the materials furnished for testing. All wire or bars of each size from each mill lot and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed in the site shall be like-

TABLE 512.7.11

FRICTION COEFFICIENTS

Type of Steel	Type of Duct	K	U
Bright metal wire or strand	Bright metal	0.002	0.30
	Galvanized	0.0015	0.25
Bright metal bars	Bright metal	0.0003	0.20
	Galvanized	0.0002	0.15

wise identified. All unidentified prestressing steel, anchorage assemblies, or bar couplers received at the site will be rejected. The following samples of material and tendons, selected by the ENGINEER from the prestressing steel at the plant or job site, shall be furnished by the CONTRACTOR to the ENGINEER well in advance of anticipated use:

512.9.1.1 For wire or strand, one 7 foot long sample shall be furnished for each heat or reel; and for bars, one 6 foot long sample shall be furnished for each heat.

512.9.1.2 If the prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon 5 feet in length for each size of tendon shall be furnished, including anchorage assemblies. If the prestressing tendon is to be assembled at the job site, sufficient wire or strand and end fittings to make up one complete prestressing tendon 5 feet in length for each size of tendon shall be furnished, including anchorage assemblies.

512.9.1.3 If the prestressing tendon is a bar, one 6 foot length complete with one end anchorage shall be furnished; and in addition, if couplers are to be used with the bars, two 3 foot lengths of bar equipped with one coupler and fabricated to fit the coupler shall be furnished.

512.9.2 Prestressing systems previously tested and approved need not be furnished as complete tendon samples, provided there is no change whatsoever in the material, design, or details previously approved. Shop drawings shall contain an identification of the project on which approval was obtained, otherwise sampling will be necessary. For prefabricated tendons, the CONTRACTOR shall give the ENGINEER at least 10 days notice before commencing the installation of end fittings or the heading of wires. The ENGINEER may inspect all end fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for all required testing of the material to be shipped to the site. No prefabrication tendon shall be shipped to the site without first having been released by the ENGINEER, and each tendon shall be tagged before shipment for identification purposes at the site. All unidentified tendons received at the site will be rejected. Job site or site as referred to herein shall be considered to mean the location where the members are to be manufactured, whether at the project site or a removed casting yard.

The release of any material by the ENGINEER shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

512.10 HANDLING

Extreme care shall be exercised in handling, storing, moving, and erecting precast prestressed concrete members to avoid twisting, racking, or other distortion that would result in cracking or damage to the members. Precast prestressed members shall be handled, transported, and erected in an upright position; and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position. Precast prestressed concrete members shall be placed in the structure in conformity with the plans and Supplementary Specifications. Precast prestressed concrete piling shall be placed in accordance with the provisions for concrete piling.

512.11 MEASUREMENT AND PAYMENT

Precast prestressed concrete members will be measured using the unit quantities for furnishing precast prestressed concrete members of the various types and lengths as outlined in the Bid Proposal or quantities for erecting the members as shown in the Bid Proposal. When various lengths or types of members are grouped together for measurement, the basis of grouping will be shown on the Bid Proposal. This measurement shall include furnishing all labor, materials, tools, equipment, and incidentals for completing all work involved and ready for erection, as shown on the plans and as provided in these specifications, the Supplementary Specifications, or as directed by the ENGINEER. Measurement also includes furnishing and placing transverse connections, anchor rods, lifting eyes, expansion joint material, as well as grouting spaces and recesses between the members.